

Evaluation of Sustainable Design Strategies and Environmental Management Practices in Airport Terminals in Nigeria

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Abstract

Airport operations contribute significantly to environmental degradation through high energy consumption, greenhouse gas emissions, noise pollution, waste generation, water contamination, and ecological disturbance. Despite growing global emphasis on sustainable airport development, limited empirical evidence exists regarding the implementation of sustainable design and environmental management practices in Nigerian airport terminals. This study assessed the extent of sustainability implementation in selected Nigerian airports and identified key areas requiring improvement. A cross-sectional exploratory research design was adopted, combining structured questionnaire surveys and field observations. Seven operational airports, comprising both international and domestic facilities, were purposively selected for investigation. Data were collected from 61 valid respondents and analysed using descriptive statistical techniques. The assessment focused on sustainability indicators including natural lighting, natural ventilation, renewable energy integration, water conservation, waste management, emissions control, noise abatement, biodiversity conservation, and sustainability governance. The findings revealed that natural lighting and sustainable material use were widely implemented across the airports. However, natural ventilation, renewable energy adoption, and water conservation measures were poorly implemented. While waste management practices were moderately adopted, noise control measures exhibited varying levels of implementation. Respondents also identified concerns relating to emissions management, environmental pollution, and biodiversity conservation. Furthermore, international airports demonstrated stronger performance in resource conservation and environmental management practices than domestic airports. The study concludes that although awareness of sustainability principles exists within the Nigerian aviation sector, significant implementation gaps remain. It recommends increased investment in renewable energy technologies, integrated water management systems, biodiversity conservation initiatives, and stronger environmental governance to enhance the sustainability and operational efficiency of airport infrastructure in Nigeria.

Keywords: Airport Terminal, Environmental Management Practices, Green Infrastructure, Resource Conservation, Sustainable Design Strategies.

Introduction

Sustainable design practices in airport terminal buildings have emerged as critical considerations in addressing the environmental challenges associated with the aviation industry (Carlucci et al., 2018; Jia et al., 2023; Mancinelli et al., 2021; Rupcic et al., 2023). Airports are significant consumers of energy and resources, contributing notably to greenhouse gas emissions and ecological degradation (Budd et al., 2016; Greer et al., 2020; Dehkordi et al., 2019). As air travel continues to expand globally, the imperative to integrate sustainability into airport operations becomes increasingly urgent. Effective sustainable design not only mitigates the environmental footprint but also enhances operational efficiency and passenger experience (Carlucci et al., 2018; Dimitriou & Karagkouni, 2022). The foundation of sustainable design lies in principles aimed at minimizing environmental impact while maximizing resource efficiency and user satisfaction (Esau, 2023). In the context of airport terminals, sustainable strategies encompass a wide array of practices, including the use of natural lighting, energy-efficient technologies, and sustainable materials throughout construction and operations (Baxter et al., 2019; Kılış, 2014). Research indicates that implementing green building practices can significantly reduce energy consumption and operational costs, thus fostering a more sustainable aviation sector (Baxter et al., 2019; Monsalud et al., 2015; Wang & Song, 2020).

In Nigeria, the aviation industry faces unique challenges that complicate the adoption of these sustainable practices. Factors such as inadequate infrastructure and limited financial resources hinder progress toward sustainability (Ahmad et al., 2024). Despite these obstacles, there is a growing recognition of the importance of environmental management in aviation, as evidenced by initiatives from regulatory bodies like the Nigerian Civil Aviation Authority (NCAA). The NCAA has introduced environmental guidelines aimed at promoting sustainable practices in airport operations, signalling a shift towards more responsible management of resources. Furthermore, several airports worldwide serve as benchmarks for successful sustainable design, showcasing innovative approaches such as rainwater harvesting, solar energy integration, and advanced waste management systems (Baxter et al., 2018a; Baxter et al 2018b; Kim et al., 2014).

Despite the growing body of literature on airport sustainability, most empirical studies have focused on airports in Europe, North America, and Asia (Jia et al., 2023), where sustainability assessment frameworks and green airport initiatives are more advanced. In contrast, limited empirical evidence exists regarding the implementation of sustainable design strategies and environmental management practices within airport terminals in developing countries, particularly Nigeria. Existing studies in the Nigerian aviation sector have largely concentrated on aviation emissions, energy challenges, and policy issues, with little attention given to the combined assessment of sustainable design features, environmental management practices, and stakeholder perceptions.

Consequently, there remains insufficient understanding of the extent to which sustainability principles have been integrated into Nigerian airport terminals. This study addresses this gap by providing an empirical assessment of sustainable design and environmental management practices across selected Nigerian airports. By examining these practices and their applicability to the Nigerian context, this study provides a comprehensive assessment of the current state of sustainable design in Nigeria's airport terminal buildings, ultimately contributing to the discourse on environmental sustainability.

Aim and Objectives

The study evaluated the implementation of sustainable design strategies and environmental management practices in selected airport terminals in Nigeria. Specifically, the objectives were to:

- i. Assess the sustainable design strategies adopted in Nigerian airport terminals.
- ii. Examine environmental management practices relating to emissions, noise, water resources, and biodiversity conservation.
- iii. Evaluate airport personnel perceptions regarding sustainability implementation.
- iv. Identify areas requiring improvement to enhance sustainable airport development in Nigeria.

Methodology

Research Design and Study Population

This study adopted a cross-sectional exploratory research design to assess the implementation of sustainable design strategies and environmental management practices in airport terminal buildings across Nigeria. A cross-sectional design was considered appropriate because the study sought to obtain a snapshot of sustainability practices across multiple airport terminals within the same period, thereby enabling comparison between facilities operating under different infrastructural and operational conditions. The exploratory nature of the study was suitable because empirical evidence on airport sustainability implementation in Nigeria remains limited, requiring an investigation capable of identifying prevailing practices and implementation gaps.

The target population comprised all operational airports in Nigeria. At the time of the study, twenty-seven (27) airports were operational, serving both domestic and international aviation activities. These airports vary considerably in terms of passenger traffic, operational complexity, terminal infrastructure, and environmental management systems. Given the study's focus on sustainability practices within airport terminals, emphasis was

placed on airports with established terminal facilities and continuous operational activities capable of providing relevant information for sustainability assessment.

Sampling Procedure and Airport Selection

A purposive sampling technique was adopted to identify airports that possess the requisite physical infrastructure, operational complexity, and environmental management systems relevant to the objectives of the study. This non-probability sampling approach is widely employed in sustainability and built-environment research where cases are selected based on their ability to provide rich and relevant information.

Seven airports were purposively selected because they represent the major operational airport terminals within Nigeria, comprising both international and domestic facilities. Collectively, these airports accommodate a substantial proportion of the country's passenger movement and exhibit varying operational scales, infrastructure, and environmental management practices. The inclusion of both international and domestic airports enhanced the diversity of the sample and enabled meaningful comparison across different categories of airport operations. The final sample consisted of seven airports and is presented in table 1.

Table 1: List of airports in the sample size

S/N	Airport	Category
1	Murtala Muhammed International Airport, Ikeja, Lagos	International
2	Nnamdi Azikwe International Airport, Federal Capital Territory	International
3	Akanu Ibiam International Airport, Enugu	International
4	Margaret Ekpo International Airport, Calabar	Domestic
5	Kaduna International Airport, Kaduna	Domestic
6	Sam Mbakwe International Cargo airport, Owerri	Domestic
7	Ibadan Airport, Oyo state	Domestic

Although the sample represents approximately 26% of Nigeria's operational airports, the selected facilities comprise the country's major airport terminals and therefore provide adequate coverage of airports with established infrastructure relevant to the objectives of the study.

Data Collection and Sustainability Assessment Framework

Two complementary data collection methods were employed to enhance the robustness of the findings: questionnaire surveys and structured field observations. A total of 86 questionnaires were distributed to selected airport stakeholders, including civil aviation personnel, airline staff, maintenance personnel, security personnel, travel agents, and cargo operators. Out of this, 68 questionnaires were retrieved, while 61 valid responses

were used for analysis after data screening. These respondents were selected due to their knowledge of airport facilities, operational processes, and environmental management practices. The questionnaire comprised four sections. Section A collected demographic information, while Sections B–D assessed sustainable design strategies, environmental management practices, and respondents' perceptions using dichotomous and five-point Likert-scale questions adapted from previous airport sustainability studies.

The sustainability assessment adopted in this study was based on an indicator-based assessment framework synthesised from established airport sustainability literature (Baxter et al., 2019; Dimitriou & Karagkouni, 2022; Jia et al., 2023). The framework comprises seven principal dimensions, namely energy efficiency, renewable energy integration, water resource management, emissions control, noise management, biodiversity conservation, and sustainability governance.

The structured field observations were conducted at each airport using an observation checklist developed from established airport sustainability assessment criteria. The checklist was used to evaluate the presence or absence of sustainable design features such as natural lighting, natural ventilation systems, renewable energy technologies, water conservation facilities, landscaping measures, and environmental management infrastructure.

Instrument Validity and Reliability

The questionnaire was subjected to expert review by three specialists in sustainable architecture, aviation infrastructure, and environmental management. The experts evaluated the relevance, clarity, completeness, and alignment of each questionnaire item with the study objectives. Their recommendations informed revisions to improve the content validity of the instrument prior to pilot testing. The pilot study produced a Cronbach's Alpha coefficient of 0.84, indicating satisfactory internal consistency of the questionnaire.

To enhance the credibility of the findings, data obtained from questionnaire surveys were triangulated with structured field observations. The observational assessment provided independent verification of sustainability practices reported by respondents, thereby strengthening the validity of the findings and reducing the influence of respondent bias.

Data Analysis

Data obtained from the questionnaire survey and field observations were analysed using Statistical Package for the Social Sciences (SPSS) version 27. Descriptive statistical techniques, including frequencies, percentages, mean scores, and ranking indices, were employed to determine the extent of sustainability implementation across the selected

airports. Comparative analyses were also conducted between international and domestic airports to identify variations in sustainable design practices and environmental management performance.

Ethical Considerations

Ethical principles guiding research involving human participants were strictly observed throughout the study. Participation in the questionnaire survey was entirely voluntary, and respondents were informed of the purpose of the research before data collection commenced. Informed consent was obtained from all participants, and respondents were assured that their identities and responses would remain anonymous and confidential. No personal identifiers were collected, and the information obtained was used solely for academic and research purposes.

Results

Sustainable Strategies in Nigerian Airports

Figure 1 presents the observed implementation of sustainable design strategies across the sampled Nigerian airports.

S/N	Airport	Natural Lighting	Natural Ventilation	Alternative Energy	Water Conservation	Waste Management	Material Use	Noise Abatement
1	Murtala Muhammed Airport, Lagos	✓	✗	✓	✓	✓	✓	⚠
2	Nnamdi Azikiwe Airport, Abuja	✓	✗	✓	✓	✓	✓	✓
3	Akara Ibiam Airport, Enugu	✓	✗	✗	✗	✓	✓	⚠
4	Margaret Ekpo Airport, Calabar	✓	✓	✗	✗	✗	✓	✓
5	Kaduna Airport	✓	✗	✗	✗	✗	✓	✓
6	Sam Mbakwe Cargo Airport, Owerri	✓	✗	✗	✗	✓	✓	✓
7	Ibadan Airport, Oyo	✓	✗	✗	✗	✓	✓	⚠

LEGEND

✓ Implemented ⚠ Partially Implemented ✗ Not Implemented

Figure 1: Observed sustainable design strategies in Nigerian Airports

Source: Authors' Fieldwork, 2026

Natural lighting was fully implemented across all airports, demonstrating widespread adoption of daylighting strategies within terminal buildings. In contrast, natural ventilation was largely neglected, with only one airport incorporating passive ventilation measures, while the majority relied on mechanical ventilation systems. The assessment also revealed limited adoption of alternative energy technologies, with approximately 71% of the airports showing no evidence of renewable alternative energy implementation and continuing to

depend primarily on grid electricity and diesel-powered generators. Similarly, observed water conservation measures were poorly implemented, indicating limited attention to resource-efficient water management practices. Conversely, sustainable material use was consistently observed across all airports, reflecting a preference for durable building materials in terminal construction. Waste management practices were also relatively well established, with the majority of airports demonstrating evidence of waste management initiatives. Noise abatement measures exhibited varying levels of implementation, ranging from partial to full adoption across the sampled airports. Overall, the findings reveal that while certain sustainability strategies such as natural lighting, material use, and waste management have gained considerable acceptance, significant gaps remain in the areas of renewable energy integration, natural ventilation, and water conservation.

Sustainable Practices and Perceptions among Airport Workers

The analysis of the questionnaire distributed to airport workers, as summarized in table 2, provides valuable insights into the demographics and categories of respondents involved in this study.

Table 2: Demographic characteristics of respondents

Variable / Category	Frequency (n = 61)	Percentage (%)
Respondent Category		
Civil Aviation Staff	20	32.8
Airline Staff	10	16.4
Travel Agents	6	9.8
Maintenance Staff	14	23.0
Cargo Consolidators	5	8.2
Security Agents	6	9.8
Total	61	100.0
Gender		
Male	28	46.0
Female	33	54.0
Total	61	100.0
Age Range (Years)		
Below 18	0	0.0
19–30	22	36.1
31–40	23	37.7
41–50	10	16.4
51 and above	6	9.8
Total	61	100.0
Marital Status		

Variable / Category	Frequency (n = 61)	Percentage (%)
Single	17	27.9
Married	44	72.1
Total	61	100.0
Educational Qualification		
WAEC/SSCE	9	14.8
ND/NCE	16	26.2
B.Sc/HND	16	26.2
MSc/MBA	11	18.0
Ph.D.	9	14.8
Total	61	100.0

Source: Authors' Fieldwork, 2026

The respondents comprised airport personnel from diverse professional backgrounds, with civil aviation staff and maintenance personnel constituting the largest categories. Most respondents possessed tertiary-level qualifications, indicating adequate knowledge and experience to provide informed responses regarding sustainability practices within airport operations.

Aircraft and Vehicular Emissions in the Airport

This section delves into the critical issue of emissions control within the airport vicinity and the findings are presented in figure 2.

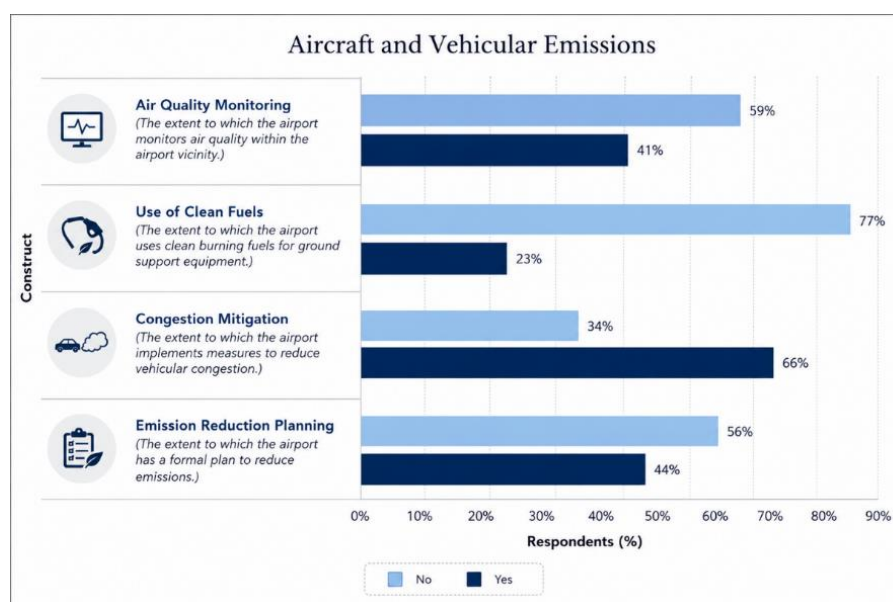


Figure 2: Aircraft and vehicular emissions in the airports

Source: Authors' Fieldwork, 2026

As illustrated in figure 2, 56% of respondents indicated that plans for reducing emissions around the airport are actively enforced. However, a significant concern remains, as 34% of participants highlighted traffic congestion as an ongoing issue that has not been adequately addressed. Additionally, 59% of respondents confirmed that regulatory bodies monitor air quality both inside the terminal buildings and in the surrounding areas.

Airport Noise Pollution

Noise pollution is one of the major issues associated with airport operations, and this formed the premise for this section in the questionnaire with the findings presented in figure 3.

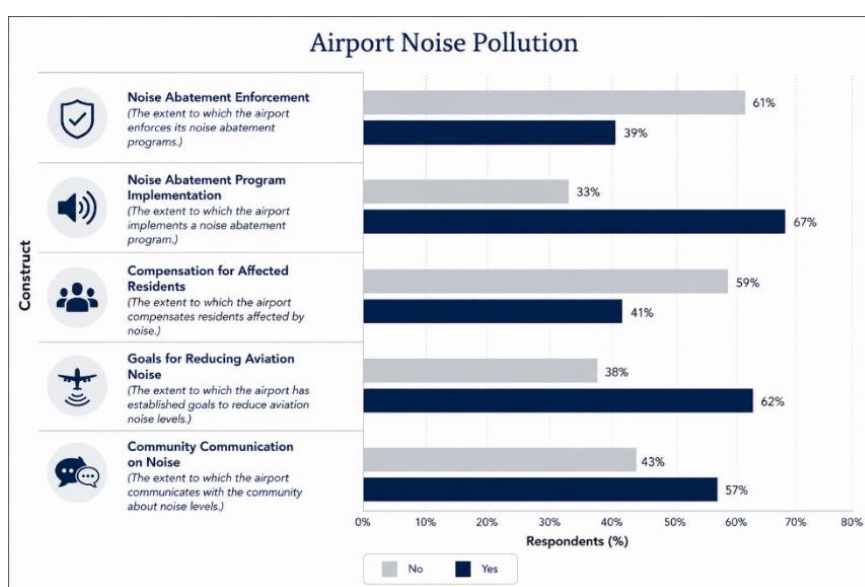


Figure 3: Noise pollution in the airports

Source: Authors' Fieldwork, 2026

Figure 3 shows 57% of the respondents said residents around the airport community complained of high noise levels, 41% identified that compensation plans were put in place for the affected residents. 62% revealed that the airports had noise abatement plans in place but 61% argued that implementation of the plan was not efficient.

Storm and Rain Water Management

In response to close-ended questions regarding water management practices, the data presented in figure 4 presents responses.

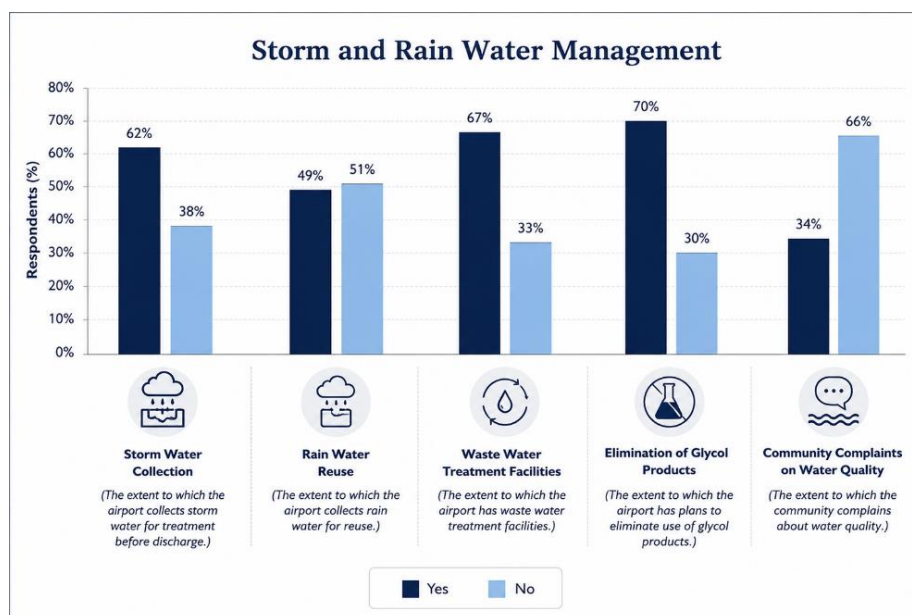


Figure 4: Storm and rain water management

Source: Authors' Fieldwork, 2026

The figure above indicates that 62% of respondents confirmed the collection and treatment of stormwater before its release. Furthermore, 49% reported the collection of rainwater for reuse outside the airport buildings, reflecting a proactive approach to water conservation and differing view from that the researchers observed physically. Additionally, 67% of respondents noted the availability of facilities for water treatment, which suggests that infrastructure is in place to support effective water management. However, a significant concern emerged, as 34% of respondents indicated that residents in the surrounding community have complained about poor water quality linked to airport operations.

Energy Consumption

Efficiency of energy is a key requirement of sustainability and the results on energy and sources in airports is presented in figure 5.

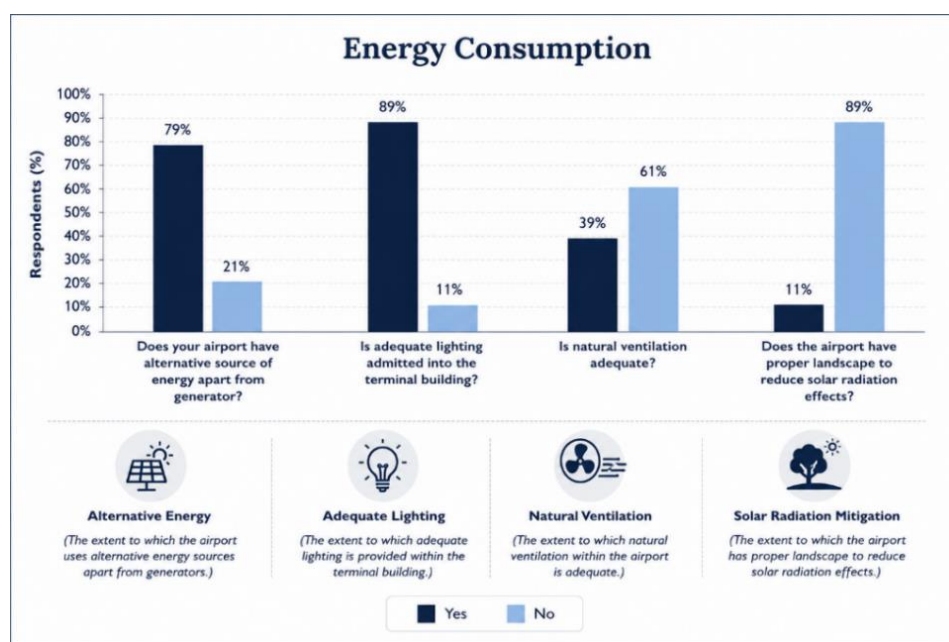


Figure 5: Energy consumption and sources in airports

Source:Authors' Fieldwork, 2026

Respondents were asked close ended questions with regards to energy consumption and sources. Figure 5 shows 79% of the respondents reported that the airport depends solely on power from generators and Power Holding Company of Nigeria (PHCN), 88% reported that the amount of natural lighting admitted into the terminal buildings is enough. 61% stated that natural ventilation was completely neglected; the 39% that reported it was adequate were workers whose offices had projected windows. 89% of the reports reported that landscaping was not properly done to reduce the negative effect of solar radiation.

Preservation of Nature and Biodiversity

Considering the adverse effects of airport operations on the eco system, it is imperative to adopt strategies that will protect the ecology. To this note, questions were asked on how airports preserved nature in their activities and the findings are presented in figure 6.

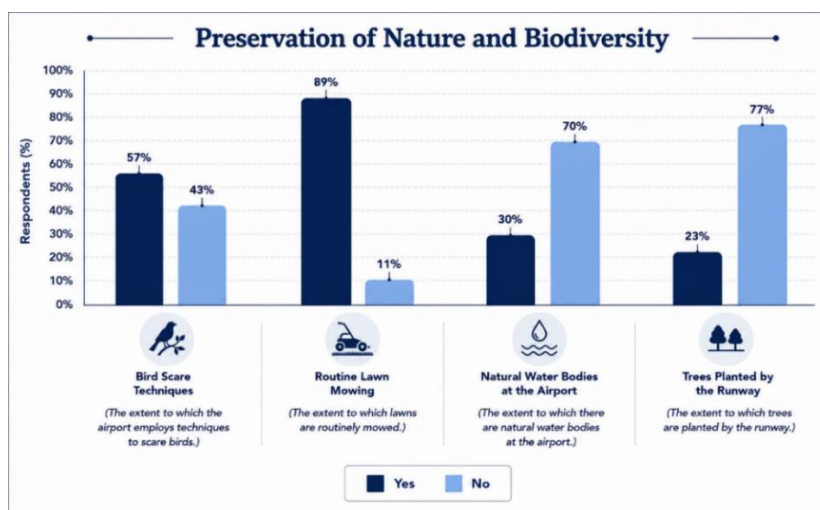


Figure 6: Preservation of nature and biodiversity

Source: Authors' Fieldwork, 2026

The findings shows 43% reported that techniques to scare birds aware from the runway way employed, 89% reported that lawns were routinely mowed and 70% stated that there are no natural water bodies in the airport.

Airport Sustainable Regulations

Airport regulations are meant to checkmate activities that are carried out within the airport vicinity. The workers were asked yes or no close ended questions regarding sustainable regulations and the results are presented in figure 7.

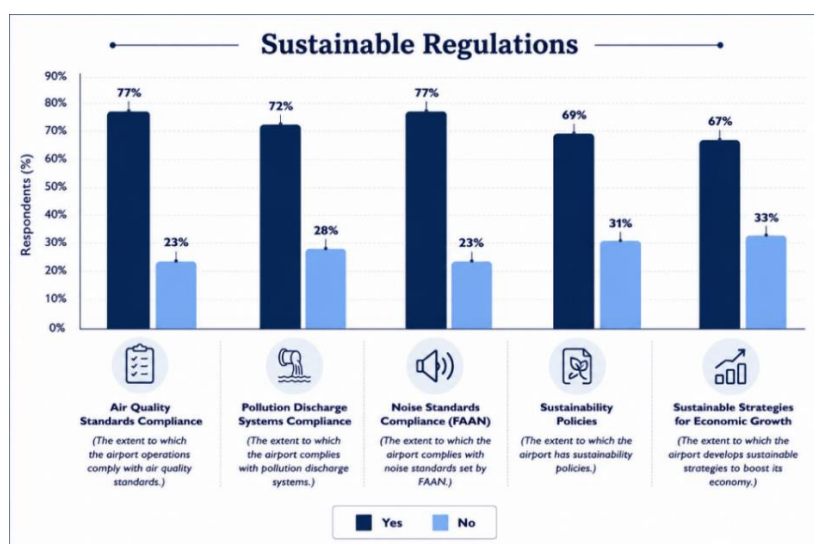


Figure 7: Sustainability regulations in airports

Source: Authors' Fieldwork, 2026

The figure shows that 77% respondents perceived that airport comply with air quality standards, 72% reported that pollution discharge regulations are been adhered to, 77% stated that noise levels were in line with FAAN standards, 69% reported that airports had personal sustainability policies employed to circumvent operational costs.

Airport Sustainable Strategies

This section employs a five-point Likert scale to gauge respondents' perceptions regarding green strategies beneficial to airports and the results are presented in Figure 8.



Figure 8: Beneficial sustainability strategies in airports

Source: Authors' Fieldwork, 2026

The findings highlight several critical areas for improvement. Notably, noise control emerged as a significant concern, indicating that addressing sound pollution is essential for enhancing the quality of life for both airport staff and surrounding communities. Additionally, the emphasis on the efficient use of water and energy resources reflects a growing awareness of the importance of sustainability in airport operations. Respondents also recognized the need to optimize natural lighting, which can reduce reliance on artificial lighting and lower energy costs.

Comparison Between International and Domestic Airports

The comparative assessment indicates notable differences in the implementation of sustainability practices between international and domestic airports as presented in table 3.

Table 3: Comparison of Sustainability Practices between International and Domestic Airports

Sustainability Indicator	International Airports (n = 3)	Domestic Airports (n = 4)	Observation
Natural Lighting	3 (100%)	4 (100%)	Fully implemented
Natural Ventilation	0 (0%)	1 (25.0%)	Generally neglected; but common for such buildings
Alternative Energy	2 (66.7%)	0 (0%)	More prevalent in international airports
Water Conservation	2 (66.7%)	0 (0%)	Implemented only in international airports
Waste Management	3 (100%)	2 (50.0%)	Better implementation in international airports
Sustainable Material Use	3 (100%)	4 (100%)	Fully implemented
Noise Abatement	1 Fully Implemented (33.3%); 2 Partially Implemented (66.7%)	3 Fully Implemented (75.0%); 1 Partially Implemented (25.0%)	Domestic airports demonstrated stronger implementation

Source: Authors' Fieldwork, 2026

Natural lighting and sustainable material use were fully implemented across both airport categories, demonstrating widespread adoption of these sustainability measures. However, international airports exhibited stronger performance in alternative energy

utilization, water conservation, and waste management, suggesting greater investment in environmental infrastructure and resource management systems. In contrast, natural ventilation was largely neglected across all airports, with only one domestic airport incorporating this passive design strategy. Noise abatement measures were more effectively implemented in domestic airports, where the majority demonstrated full compliance compared to international airports, which relied more on partial implementation measures.

Discussion of Findings

Sustainable Design Strategies and Energy Performance

The observational assessment revealed widespread adoption of natural lighting across all sampled airports, indicating recognition of daylighting as a passive design strategy capable of reducing electricity consumption. This finding is consistent with Dehkordi et al., (2019), who stated that sustainable airport terminals benefit significantly from daylight optimization and renewable energy integration, leading to improved environmental performance and reduced operational energy demand. Eze et al., (2025), also emphasized that adequate daylighting contributes to improved visual comfort and recommended the integration of design features such as clerestories, light pipes, and appropriate shading devices to maximize natural illumination while minimizing glare. Despite the extensive use of natural lighting, natural ventilation was largely absent in most terminals, with airport facilities relying predominantly on mechanical cooling and ventilation systems as the case is in other countries for this type of infrastructure.

This finding supports the observations of Kılış, (2014), who identified airport terminals as highly energy-intensive facilities due to extensive dependence on artificial environmental control systems. The findings also corroborate those of Baxter et al. (2018b), who argued that energy-efficient airport management increasingly depends on integrating passive environmental strategies alongside active building systems. The limited application of natural ventilation in Nigerian airports therefore suggests significant opportunities for reducing energy consumption and operational costs.

The study further revealed limited adoption of renewable energy technologies, with only a small proportion of airports incorporating solar photovoltaic systems. This finding aligns with Oluwakayo, (2023), who identified inadequate investment in renewable energy infrastructure as a major challenge limiting sustainable transitions within the Nigerian aviation sector. Similarly, Ajayi et al., (2025) observed that although African airports increasingly recognize the benefits of clean energy technologies, implementation remains constrained by financing, technical expertise, and policy support. In contrast, airports in Europe and Asia have increasingly adopted solar power systems and energy management

frameworks as part of broader decarbonization strategies (Dimitriou & Karagkouni, 2022; Wang & Song, 2020). The continued dependence on diesel-powered generators is also indicative of broader infrastructural challenges within Nigeria's energy sector. Frequent power supply interruptions and inadequate grid reliability have compelled many airports to maintain generator-based backup systems as a primary source of operational energy. While this approach ensures operational continuity, it increases fuel consumption, operational expenditure, and greenhouse gas emissions.

Environmental Pollution, Emissions and Noise Management

The findings indicate that most respondents acknowledged the existence of air quality monitoring systems and emissions reduction initiatives. However, traffic congestion and vehicular emissions remain substantial concerns. These results are consistent with Budd et al., (2016), who emphasized that airport sustainability extends beyond terminal operations and requires effective management of airport surface access systems. Likewise, Monsalud et al., (2015), reported that emissions from airport support operations and ground transportation constitute significant contributors to the environmental footprint of airports and should be addressed through integrated mitigation strategies.

Noise pollution emerged as one of the most critical environmental concerns identified by respondents. Although the majority reported the existence of noise abatement programmes, many indicated that implementation remains ineffective, while communities surrounding airport facilities continue to experience significant noise disturbances. This finding supports Dimitriou & Karagkouni, (2022), who argued that environmental sustainability performance depends not merely on the existence of environmental policies but on their effective implementation and monitoring. Similar concerns have been reported globally, where airport expansion has often generated conflicts between operational growth and community well-being (Greer et al., 2020). The persistence of community complaints in the present study suggests that existing noise management measures may be inadequate in mitigating the social impacts of airport operations. The findings further suggest that environmental management within Nigerian airports remains largely reactive rather than preventive. Although monitoring programmes and mitigation plans exist, implementation effectiveness appears limited, indicating a need for stronger institutional capacity and environmental enforcement mechanisms.

Water Management and Resource Conservation

Water management practices within the sampled airports demonstrated mixed performance. While the majority of respondents reported the existence of stormwater collection and treatment systems, water conservation and reuse strategies remained limited and were not observed. These findings contrast with those of Baxter et al. (2019),

who documented comprehensive water management programmes at Copenhagen Airport, including rainwater harvesting, wastewater recycling, and water consumption monitoring systems. Such initiatives have enabled significant reductions in potable water demand and improved environmental performance. The relatively low adoption of water reuse systems in Nigerian airports is particularly concerning given increasing water scarcity challenges across many developing regions. According to Jia et al., (2023), resource efficiency and environmental resilience have become critical indicators within contemporary airport sustainability assessment frameworks. The limited implementation of water conservation strategies identified in this study therefore suggests an important area requiring policy intervention and infrastructural investment.

Biodiversity Conservation and Ecological Sustainability

The findings revealed limited biodiversity conservation initiatives beyond routine landscape maintenance and bird control measures. While vegetation management was commonly practiced, ecological conservation was primarily driven by operational safety requirements rather than environmental stewardship objectives. Similar observations were reported by Rupcic et al., (2023), who noted that biodiversity protection remains one of the least developed dimensions of airport sustainability despite increasing concern regarding habitat degradation and ecosystem disruption associated with aviation infrastructure. Furthermore, Mancinelli et al., (2021), found that airports demonstrating higher sustainability performance tend to integrate biodiversity management, ecological restoration, and environmental monitoring into broader sustainability programmes. The limited ecological initiatives observed in Nigerian airports therefore indicate that biodiversity considerations have not yet been fully incorporated into airport sustainability planning and management.

Sustainability Governance and Regulatory Compliance

A notable finding of this study is the relatively high level of perceived compliance with environmental regulations relating to air quality, pollution control, and noise management. However, the simultaneous identification of significant implementation gaps suggests that regulatory compliance does not necessarily translate into effective sustainability performance. This observation supports Carlucci et al., (2018), who found that airport sustainability outcomes depend not only on regulatory frameworks but also on institutional capacity, management commitment, and implementation effectiveness. The strong support expressed by respondents for renewable energy adoption, water conservation measures, natural ventilation strategies, and sustainable airport planning indicates growing environmental awareness among airport personnel. This finding aligns with Dimitriou &

Karagkouni, (2022), who identified environmental awareness as a critical driver of sustainability performance within airport organizations. Similarly, Jia et al., (2023), emphasized that future airport sustainability depends on integrating environmental considerations into strategic planning, operational management, and infrastructure development processes.

Overall, the findings demonstrate that Nigerian airports exhibit increasing awareness of sustainability principles but remain constrained by limited renewable energy deployment, inadequate water conservation systems, weak biodiversity management practices, and challenges in implementing environmental policies. Consequently, achieving sustainable airport development will require stronger institutional frameworks, investment in green infrastructure, and the integration of sustainability considerations into airport planning, design, and operations.

Conclusion and Recommendations

The findings reveal that while certain sustainability measures, particularly natural lighting and basic environmental regulatory compliance, have been incorporated into airport operations, the overall level of sustainability implementation remains low. Significant deficiencies were observed in the adoption of natural ventilation systems, renewable energy technologies, water conservation measures, biodiversity management initiatives, and effective noise and emissions mitigation strategies. The results further indicate a continued dependence on conventional energy sources, particularly diesel generators and grid electricity, alongside inadequate integration of resource-efficient infrastructure. Although airport personnel demonstrated considerable awareness of sustainability issues and expressed support for environmentally responsible operational practices, a substantial gap remains between sustainability objectives and practical implementation. The study contributes empirical evidence on the current state of sustainability implementation within Nigerian airport terminals and highlights critical areas requiring intervention to align airport operations with emerging global sustainability standards.

Based on the findings, the following recommendations are proposed:

1. **Renewable energy integration** should be prioritized through the deployment of solar photovoltaic systems and other clean energy technologies to reduce dependence on diesel generators and grid electricity.
2. **Passive design strategies**, including natural ventilation in office spaces and climate-responsive architectural solutions, should be incorporated into future airport terminal developments and renovation projects.
3. **Integrated water management systems**, including rainwater harvesting, stormwater reuse, and water-efficient fixtures, should be adopted to improve resource conservation and environmental performance.

4. **Noise and emissions management programmes** should be strengthened through continuous monitoring, improved traffic management, and stricter implementation of mitigation measures around airport environments.
5. **Biodiversity conservation initiatives** should extend beyond routine landscaping to include ecological management plans, habitat preservation measures, and the use of native vegetation within airport developments.
6. **Government agencies and airport authorities** should strengthen sustainability regulations and provide incentives that encourage the adoption of green technologies and sustainable operational practices across Nigerian airports.

The implementation of these recommendations will enhance environmental performance, improve operational efficiency, reduce long-term operating costs, and support the transition toward more sustainable and resilient airport infrastructure in Nigeria.

Study Limitations and Future Directions

This study was limited to seven operational airports selected through purposive sampling and therefore may not fully represent all airports within Nigeria. Access restrictions within airport facilities and the operational schedules of personnel constrained the number of respondents available for participation, resulting in a relatively small sample size. Consequently, some stakeholder groups were underrepresented in the survey, which may have influenced the comprehensiveness of the perspectives obtained.

Furthermore, some findings were based on respondents' perceptions and may be influenced by personal experiences, professional responsibilities, and organizational perspectives. The study also relied primarily on questionnaire responses and field observations, without access to detailed operational datasets such as energy consumption records, carbon emission inventories, water usage data, and waste generation statistics. Future studies should incorporate these objective environmental performance indicators and expand stakeholder participation across a larger number of airports to provide a more comprehensive and generalizable assessment of airport sustainability performance in Nigeria.

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